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In re PATENT APPLICATION of

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Title: BOILING COOLER FOR COOLING HEATING ELEMENT BY HEAT TRANSFER WITH BOILING

VERIFIED TRANSLATION OF PRIORITY DOCUMENT

The undersigned, of the below address, hereby certifies that he/she well knows both the English and Japanese languages, and that the attached is an accurate translation into the English language of the Certified Copy, filed for this application under 35 U.S.C. Section 119 and/or 365, of:

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Signed this 27 day of April, 2004.

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Commissioner,

Patent Office Kozo Oikawa

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[NAME OF THE DOCUMENT] SPECIFICATION

[THE TITLE OF THE INVENTION] BOILING COOLER

[CLAIMS]

WHAT IS CLAIMED IS:

1. A boiling cooler for cooling a heating element by heat transfer of boiled refrigerant in a heat exchange part, wherein:

refrigerant vapor boiled and gasified by heat from the heating element exchanges heat with a liquid.

2. The boiling cooler according to claim 1, wherein the heat exchange part defines therein a vapor passage in which the boiled refrigerant vapor flows and a coolant passage that is adjacent to the vapor passage, and the liquid flows through the coolant passage.

3. The boiling cooler according to claim 2, further comprising a tank defining a refrigerant chamber for storing a liquid refrigerant therein with a liquid surface, wherein:

the vapor passage is provided above the liquid surface inside the tank.

4. The boiling cooler according to claim 2 or claim 3, wherein:

the tank is separated from the coolant passage by a boundary wall that has a convexo-concave shape.

5. The boiling cooler according to claim 4, wherein:

the height of convex portion of the tank protruding to the coolant passage side is highest in the proximity of the center of a left-right direction or a front-rear direction

with decreasing height toward the peripheral area.

6. The boiling cooler according to claim 4 or claim 5, wherein:

the outer surface of convex portion that protrudes from the tank to the coolant passage has a fin for increasing a heat radiation surface.

7. The boiling cooler according to any one of claim 2 to claim 6, wherein:

the coolant passage is connected to a coolant channel that is equipped with a heat radiating radiator, and operation of a pump installed in the coolant channel enables the circulation of liquid in the coolant passage.

[DETAILED EXPLANATION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to a boiling cooler for cooling a heating element by heat transfer of boiled refrigerant.

[0002]

[PRIOR ART]

JP-A-8-204075, for example, is disclosed as one of the prior art of boiling cooler. This boiling cooler cools a heating element by boiling heat transfer of the refrigerant, and, owing to its higher thermal conductivity compared to the air-cooling and water-cooling method, is widely used as the cooling device for semiconductor that generates a large heat flux.

This boiling cooler is composed of a refrigerant tank

for storing liquid refrigerant, a radiator to cool the refrigerant vapor boiled in the refrigerant tank by the heat from the heating element, and a cooling fan providing cooling air to the radiator.

[0003]

[PROBLEM TO BE SOLVED BY THE INVENTION]

In the conventional boiling cooler, however, while condensation heat transfer is performed with a large thermal conductivity at the inside of the radiator, cooling with the air is performed with a smaller thermal conductivity at the outside of the radiator. Therefore, the volume of the radiator must be increased to produce a sufficient performance from air-cooling. Consequently, the installation of the boiling cooler is liable to be limited. Especially when the boiling cooler is to be mounted on an automobile or the like, its mountability is very low because it must be disposed in a small space.

The present invention has been devised in view of the above problem. An object of the present invention is to provide a boiling cooler having good mountability derived from the smaller restriction in arrangement.

[0004]

[MEANS FOR SOLVING THE PROBLEMS]

(Means for claim 1)

The boiling cooler of the present invention enables refrigerant vapor boiled and gasified by heat from a heating element to exchange heat with a liquid.

According to this invention, the refrigerant vapor can be cooled by liquid cooling with greater thermal conductivity than air cooling (for example, water cooling), the radiator needs not to have a large dimension being adopted in the air cooling of prior art. As a result, the smaller volume of the boiling cooler device can be achieved and the mountability to vehicles and the like can be improved.

[0005]

(Means for claim 2)

In the boiling cooler according to claim 1, a vapor passage in which the refrigerant vapor boiled and gasified by heat from the heating element, and a coolant passage adjacent to the vapor passage are provided. Further, the liquid flows through the coolant passage.

According to this constitution, heat is exchanged between a liquid (for example, water or oil and the like) that flows in the coolant passage and a refrigerant vapor that flows in the vapor passage, and heat of the refrigerant vapor is transferred to the liquid and expelled outside.

[0006]

(Means for claim 3)

The boiling cooler according to claim 2, wherein a tank to store a liquid refrigerant is provided, and a space as the vapor passage is provided above the surface of the liquid in the tank.

In this manner, the tank and the coolant passage can be provided adjacently, and the integration of these two

portions can be realized with less number of parts, therefore, this device can be constructed with less volume.

[0007]

(Mean for claim 4)

In the boiling cooler according to claim 2 or claim 3, the tank and the coolant passage is separated by a concavo-convex shape boundary wall.

In this case, most of the heat from the refrigerant vapor is transferred to the liquid through the boundary wall of the tank and the coolant passage. In other words, the area of the boundary wall between the tank and the coolant passage contributes the efficiency of heat transfer, the concavo-convex shape boundary wall can have a larger heat transfer area (a radiation area), resulting in a higher efficiency of heat radiation.

Furthermore, compared to the case that the boiling cooler has a flat boundary wall between the tank and the coolant passage, the liquid surface in this type of boiling cooler has a lesser movement of ups-and-downs when the device is tilted in the use on a moving body such as an automobile and the like, and, as a result, lowering of the heat radiation efficiency can be prevented.

[0008]

(Means for claim 5)

In the boiling cooler according to the claim 4, the convexo part of the tank that protrudes toward the coolant passage has the maximum height approximately at the center in

either of the front-rear or left-right direction, and the height decreases approaching to the end of both sides. By adopting this structure, a smaller change of the liquid surface height can be achieved when the boiling cooler is tilted.

[0009]

(Means for claim 6)

In the boiling cooler according to claim 4 or claim 5, on the outer surface of the convexo part that protrudes from the tank toward the coolant passage, a fin is provided for increasing a larger radiation area. In this manner, the fin increases the surface to be used for heat radiation, and thereby resulting in a higher efficiency of heat radiation by producing a larger amount of heat exchange between the refrigerant vapor and the liquid.

[0010]

(Means for claim 7)

In the boiling cooler according to claim 2 to claim 6, wherein the coolant passage is connected to the coolant channel that is equipped with the radiator for heat radiation, and operation of a pump installed in this coolant channel enables circulation of liquid in the coolant passage. According to this constitution, the radiator and the boiling cooler can be located separately, and thus the mountability of the boiling cooler can be improved.

[0011]

[EMBODIMENTS]

Preferred embodiments of the present invention are described hereinafter with reference to the accompanying drawings.

(First Embodiment)

FIG. 1 shows an A - A cross-sectional view (a) and a top view (b) of the heat diffusion block, and FIG. 4 shows the whole structure of this system.

The boiling cooler of this embodiment is formed in a box-shape and has the heat diffusion block 1 that contains a refrigerant sealed therein.

[0012]

This heat diffusion block 1 is, as shown in FIG. 1, constructed of a block body 2, two side plates 3 (in FIG. 3) that cover the openings on both sides of the block body 2, an upper lid 4 that is fixed on the upper end surface of the block body 2, and two outer plates 5 that is fixed on both sides of the block body 2.

The block body 2 has hollow shapes formed in the vertical direction of FIG. 2 (a), and also has a concavo-convex shape in the upper half of the vertical direction in FIG. 2 (b). On both of the upper and lower sides of the block body 2 in FIG. 2 (a), sealing surfaces 6 are shaped along the perimeter of the opening to be covered by the side plates 3 as shown in FIG. 2 (a). This sealing surface 6 is lowered by the thickness of the side plate 3 from the side face of the block body 2.

[0013]

The side plate 3 is, as shown in FIG. 3, formed in the shape of the opening that resides on the side of the block body 2, and can cover the opening in contact with the sealing surface 6 mentioned above.

The upper lid 4 is shaped in the size of block body 2 in the planar view, and, as shown in FIG. 1 (a), is fixed with the sealing material 7 by using bolts 8 on both of the right and left end faces of the block body 2.

The outer plates 5 are, as shown in FIG. 1 (b), externally fixed to the both side faces of the block body 2 with the sealing material 9 interposed therebetween by bolts 10. The fixation of the outer plates 5 is performed after the upper lid 4 is fixed to the block body 2. On each of these two outer plates 5, a water hole 11 is formed in the direction of the thickness penetrating the plate, and the water hole 11 has a pipe joint port 11a.

[0014]

The above-mentioned heat diffusion block 1 forms a sealed tank 12 with the hollow space in the block body 2 covered by the two side plates 3, and this tank 12 is filled with a given amount of refrigerant after deaeration and then enclosed. The tank 12 is composed of, as shown in FIG. 1 (a), a refrigerant chamber 12A which is small in height and large in both of the planar direction, and a convex shape radiation space 12B (a vapor passage of the present invention) which protrudes upward from the refrigerant chamber 12A, and a liquid refrigerant is poured to the level approximately of

the height of the refrigerant chamber 12A.

[0015]

A heating element 13 (shown in FIG. 1(a)) is fixed on the bottom face of the heat diffusion block 1 (the bottom face of the block body 2) by bolt 14, and the heat from the heating element 13 is transferred to the liquid refrigerant in the tank 12 through the bottom face of the block body 2.

Furthermore, in the heat diffusion block 1, a water passage portion 15 is provided with a hollow space that is defined between the concavo-convex portions of the block body 2 and the upper lid 4, and is closed with the two outer plates 5. As shown in FIG. 4, the water passage portion is connected to a cooling water channel 17 through a water pipe 16 connected to the pipe joint ports 11a provided at the outside of the outer plate 5. The cooling water channel 17 has a pump 18 for circulating the cooling water, and a radiator 19 for cooling the cooling water with air.

[0016]

Next, an operation of the boiling cooler in this embodiment is explained below.

Liquid refrigerant in the refrigerant chamber 12A is boiled by heat transferred from the heating element 13 through the bottom face of the refrigerant chamber 12A, and then flows, as refrigerant vapor, into the radiation space 12B of the tank 12.

On the other hand, cooling water flows into the water passage portion 15 of the heat diffusion block 1 by the

operation of the pump 18. Accordingly, refrigerant vapor in the radiation space 12B is cooled by the cooling water flowing in the water passage portion 15, and is condensed to produce liquid drops (condensate) on the inner wall of the tank 12 defining the radiation space 12B. The liquid drops drip into the refrigerant chamber 12A and return to a part of liquid refrigerant.

The cooling water that has received heat from refrigerant vapor has a raised temperature, radiates heat into atmosphere in the radiator 19 to have a lower temperature, and then returns to the water passage portion 15 again.

[0017]

(The advantages of the first embodiment)

The heat diffusion block 1 of this embodiment is so constructed that refrigerant vapor, which is boiled by heat from the heating element 13, is condensed by cooling water. This structure is suitable for cooling the heating element 13 composed of a semiconductor device capable of generating a large thermal flux. Also, in this structure, it is not necessary to have a radiator with a larger volume as used in the conventional air cooling system, resulting in size reduction of the boiling cooler. This lightens restrictions on the disposition of the heat diffusion block 1, and thus significantly improves the mountability to a vehicle and the like that has a limited space for installation.

[0018]

This heat diffusion block 1 needs not be integrated with the radiator 19, and may be disposed separately from the radiator 19 as shown in FIG. 4, thus restrictions on the disposition will not be tightend.

[0019]

Further, in the heat diffusion block 1 of the present embodiment, heat exchange between refrigerant vapor and cooling water is performed through the boundary wall of between the tank 12 and the water passage portion 15. That is, the boundary wall constitutes a heat transfer face. Therefore, the boundary face formed into the concavo-convex shape can increase a heat transfer area (radiation area).

Moreover, in comparison with the case that the boundary wall between the tank 12 and the water passage portion 15 is flat, this structure decreases the height variation of the liquid surface when the heat diffusion block 1 is tilted, resulting in the prevention of deteriorated radiation performance from the liquid surface variation.

[0020]

(Second embodiment)

FIG. 5 shows a cross-sectional view of a heat diffusion block 1.

In the heat diffusion block 1 of the present embodiment, as shown in FIG. 5, thickness t of the bottom wall of the block body 2, i.e., between the bottom face of the refrigerant chamber 12A and the outer bottom face of the block body 2 to which the heating element 13 is fixed, is

thinned except for portions 20 where screw holes for the bolts 14 are formed. In this case, in comparison with the first embodiment, heat from the heating element 13 is efficiently transferred to liquid refrigerant in the refrigerant chamber 12A, and heat transfer with boiling of refrigerant can be performed efficiently, the radiation performance can be improved.

[0021]

(Third embodiment)

FIG. 6 shows a cross-sectional view of a heat diffusion block 1.

The heat diffusion block 1 of the present embodiment has, in addition to the constitution of the second embodiment, heat radiation fins 21 in the water passage portion 15. The heat radiation fins 21 is made of, for example, aluminum, and as shown in FIG. 6, each radiation fin is inserted into a concave portion defined between neighboring two convex portions 2a of the block body 2 and is brazed to the outer walls of the convex portions 2a.

In this case, because the radiation fins 21 increases heat transfer area (radiation area), the radiation performance can be improved.

[0022]

(Fourth embodiment)

FIG. 7 shows a cross-sectional view of a heat diffusion block 1.

In the heat diffusion block 1 of the this embodiment, as

shown in FIG. 7, the convexo part 2a of the block body 2 has the maximum height approximately at the center in the direction of left-right (or front-rear) and the height decreases approaching to the end of both sides.

In this constitution, for example, if the heat diffusion block 1 is mounted on a vehicle and is tilted when the vehicle travels, the smaller amount of the refrigerant is filled in the convex portion 2a (the radiation space 12B) as compared to the cases in the first to the third embodiments, because the height of the convex portion decreases at the both sides of the tank 12. As a result, this structure lessens the height variation of the liquid surface when the heat diffusion block 1 is tilted, resulting in the prevention of the exposure of the bottom of the refrigerant chamber 12A which constitutes the boiling surface of the refrigerant and thus providing the enough performance required for cooling the heating element 13.

[0023]

(Fifth embodiment)

FIG. 8 shows a cross-sectional view of a heat diffusion block 1.

The heat diffusion block 1 in this embodiment has inner plates 22 disposed in the refrigerant chamber 12A. The inner plates 22 are made of, for example, metallic plate such as aluminum having sufficient thermal conductivity, and, as shown in FIG. 9, held by being inserted into groove portions 12a formed on the wall surface of the refrigerant chamber 12A.

Also, the inner plate 22 can have notch portions on one side of it, as shown in FIG. 9 (a), or on the other side of it, as shown in FIG. 9 (b).

In this constitution, the boiling area of the refrigerant chamber 12A can be increased by disposing the inner plates 22 in the refrigerant chamber 12A, and the radiation performance can be improved accordingly.

[0024]

(Sixth embodiment)

FIGS. 10 to 12 show an outer shape of a boiling cooler in this embodiment of the invention. Specifically, FIG. 10 is a front view of the boiling cooler, FIG. 11 is a bottom view (plan view from the side on which a heating element is attached) of the boiling cooler, and FIG. 12 is a side view (plan view from the side face of radiating portion) of the boiling cooler.

The boiling cooler 30 in this embodiment is, for example, mounted on an electric vehicle to cool an IGBT module (heating element 31 of the present invention) constituting an inverter circuit of a vehicular motor. This boiling cooler 30 is composed of, as shown in FIGS. 10 to 12, a refrigerant vessel 32 for storing liquid refrigerant therein, and radiators 33 for cooling refrigerant vapor that is boiled upon receiving heat from the heating element 31, which are made of metallic materials (for example, aluminum) having sufficient thermal conductivity.

[0025]

The refrigerant vessel 32 is a thin hollow member having a small thickness (height) in the vertical direction and a large dimension in the horizontal direction (lateral and longitudinal directions). Both ends of the refrigerant vessel 32 in the longitudinal direction are open and its inside is divided into several passage portions.

Referring to FIG. 13, inner fins 34 are inserted into the passage portions (called as vapor outflow passages 32a, hereinafter) that covers, at least, the region (boiling portion) to which the heating element 31 is attached. Each inner fin 34 can be formed, as shown in FIGS. 14(a) and 14(b), with plural notch portions 34a for the purpose to increase a heat transfer area (boiling area).

The heating element 31 is closely attached to the lower side outer surface of the refrigerant vessel 32, and is fixed thereto by bolts 35.

[0026]

The radiators 33 are respectively composed of a pair of tanks (lower tank 36 and upper tank 37) and a heat exchange part (described below), as shown in FIG. 10, and are provided at the both sides (right and left sides) of the refrigerant vessel 32 in the lateral direction.

The lower tank 36 is provided to communicate with the passage portions of the refrigerant vessel 32, and stores liquid refrigerant in cooperation with the refrigerant vessel 32. Therefore, the right side radiator 33 and the left side radiator 33 communicate with each other through the

refrigerant vessel (passage portions) 32 at the respective lower tanks 36. The refrigerant vapor boiled in the refrigerant vessel 32 flows in the right and left directions in the vapor outflow passages 32a and enters the lower tanks 36.

Besides, the liquid refrigerant is held with its surface higher than the upper surface of the refrigerant vessel 32 (FIG. 13). That is, the inside of the refrigerant vessel 32 is filled with liquid refrigerant.

[0027]

Referring to FIGS. 13 and 18, each of the lower tank 36 holds a refrigerant flow control plate 38 therein. The refrigerant flow control plate 38 forms an extension passage portion 38a for extending the vapor outflow passages 32a into the lower tank 36 to prevent, in the lower tank 36, interference between the refrigerant vapor coming out of the vapor outflow passages 32a and the condensate returned from the radiator 33 (FIG. 20).

Each upper tank 37 is positioned above the heat exchange part, and faces the lower tank 36 through the heat exchange part interposed therebetween in the vertical direction.

[0028]

The heat exchange part is, as shown in FIG. 13, composed of plural radiation passages 39 connecting the lower tank 36 and the upper tank 37, and water jackets 40 provided around the radiation passages 39. Heat exchange is performed between refrigerant vapor flowing in the radiation passages

39 and the cooling water flowing in the water jackets 40.

The radiation passages 39 respectively have an elongated rectangular opening in cross-section, and are arranged with an approximately constant interval in the width direction of the tanks 36, 37 (lateral direction in FIG. 15).

[0029]

An inner fin 41 is, as shown in FIG. 16, inserted into an inside of each radiation passage 39. The inner fin 41 is, for example, formed from a thin metallic plate, such as aluminum, bent into a corrugated shape with a given pitch. The inner fin 14 is inserted with an uneven spacing toward the both walls of the radiation passage 39 (in the right direction in FIG. 16). Accordingly, the inside of the radiation passage 39 is constituted from two parts, that is, a first passage portion (called vapor passage portion 39a hereinafter) defined at the other side of the inner fin 41 at the outside of the inner fin 41, and a second passage portion (called liquid passage portion 39b hereinafter) including plural passages defined by the inner fin 41.

[0030]

The water jackets 40 constitute passages in which cooling water flows. The water jackets 40, as shown in FIGS. 15 to 17, surround each radiation passage 39 and the entire periphery of the heat exchange part. The water jackets 40 are further connected to the cooling water channel in which cooling water circulates.

The cooling water channel is, as shown in FIG. 19, used

for a water cooling system for a vehicular motor 42 of an electric vehicle, and has a pump 43 for circulating cooling water and a radiator 44 for cooling the cooling water with air.

[0031]

The operation of this embodiment is explained below.

Liquid refrigerant stored in the refrigerant vessel 32 boils upon receiving heat from the heating element 31, and as shown in FIG. 20, flows from the vapor outflow passages 32a into the lower tank 36 through the extension passage portion 38a. After that, refrigerant vapor flows from the lower tank 36 into the vapor passage portions 39a in the radiation passages 39, rises in the vapor passage portions 39a, and flows into the upper tank 37. It further flows from the upper tank 37 into the liquid passage portions 39b defined by the inner fin 41 at the given pitch. The refrigerant vapor entering the liquid passage portions 39b is cooled by cooling water flowing in the water jackets 40, and is condensed and liquefied on the surfaces of the inner fins 42 and on the inner walls of the radiation passages 39.

[0032]

Condensate liquefied in the liquid passage portions 39b is collected and held at the lower portion of the inner fin 41 due to a surface tension, and as shown in FIG. 16, forms a liquid part at the lower portion of the inner fin 41. This liquid part prevents refrigerant vapor from entering the liquid passage portions 39b from the lower tank 36 directly,

and contributes to form a refrigerant circulating flow in the radiation passages 39 desirably.

The condensate collected in the liquid part drops sequentially into the lower tank 36 from the liquid part due to a pressure of refrigerant vapor rising in the vapor passage portions 39a.

[0033]

This boiling cooler 30 is, for example, mounted on the electric vehicle so that the longitudinal direction of the refrigerant vessel 32 (lateral direction in FIG. 10) is parallel to the front and rear direction of the vehicle, and also the refrigerant vessel 32 is level. In this case, when the vehicle travels on a slope, the refrigerant vessel 32 is tilted with respect to the horizontal plane.

Specifically, as shown in FIG. 21, the refrigerant vessel 32 may be inclined with the right side higher than the left side thereof. In this case, refrigerant vapor produced by boiling therein rises (moves toward the right side) along the inclined refrigerant vessel 32, and flows into the lower tank 36 of the right side radiator 33.

[0034]

After that, as mentioned above, condensate cooled in the radiator 33 drops in the lower tank 36. At that time, condensate dropped from the liquid part into the lower tank 36 mainly enters, from both outer sides of the refrigerant control plate 38, a passage portion (called liquid return passage 32b) of the refrigerant vessel 32 (shown in FIG. 22).

The condensate entering the liquid return passage 32b then flows in the inclined refrigerant vessel 32, enters the lower tank 36 of the left side radiator 33, and then returns to the boiling portion in the refrigerant vessel 32 from the lower tank 36 again.

[0035]

(The advantages of this embodiment)

The boiling cooler 30 in this embodiment has a structure different from those of the heat radiation blocks explained in the first to fifth embodiments; however, it is the same as those in the point that refrigerant vapor which is boiled (and gasified) upon receiving heat from the heating element 31, is cooled by water. Therefore, the boiling cooler 30 is suitable for cooling the heating element 31 including a semiconductor device and the like having a large thermal flux.

Also, because the radiators 33 are provided at the both sides of the refrigerant vessel 32, at least one of the radiators 33 performs heat exchange between refrigerant vapor and cooling water without deterioration of radiation performance even if there arises a positional difference in height between the two radiators 33. As a result, a stable radiation performance can be achieved.

[0036]

Especially when the boiling cooler 30 is mounted on a vehicle, the inclination of the vehicle is constantly changing subject to that of the road, that is, in such a condition that the inclination reverses as the travaling

vehicle enters into descending from climbing, this boiling cooler 30 is very effective because the stable radiation performance can be exhibited regardless of the inclination of the radiation vessel 32.

Furthermore, the boiling cooler 30 of the present invention is not used only for vehicles, but may be used for any transportation means such as ships (especially small-size ship capable of being swung largely) and helicopters. Otherwise, it may be used on a slope.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1]

FIG. 1 is a cross-sectional view showing a heat diffusion block taken along line A-A (a) and a plan view (b) (according to a first embodiment).

[FIG. 2]

FIG. 2 is a plan view of a block body (a) and a side view (b) (the first embodiment).

[FIG. 3]

FIG. 3 is a plan view (a) and a side view (b) of the block body with a lid attached on its side face (the first embodiment).

[FIG. 4]

FIG. 4 is a structure diagram of the whole system.

[FIG. 5]

FIG. 5 is a cross-sectional view of the heat diffusion block (a second embodiment).

[FIG. 6]

FIG. 6 is a cross-sectional view of the heat diffusion block (a third embodiment).

[FIG. 7]

FIG. 7 is a cross-sectional view of the heat diffusion block (a fourth embodiment).

[FIG. 8]

FIG. 8 is a cross-sectional view of the heat diffusion block (a fifth embodiment).

[FIG. 9]

FIG. 9 is a cross-sectional view of a tank with an inner plate (the fifth embodiment).

[FIG. 10]

FIG. 10 is a front view of a boiling cooler (a sixth embodiment).

[FIG. 11]

FIG. 11 is a bottom view of the boiling cooler (the sixth embodiment).

[FIG. 12]

FIG. 12 is a side view of the boiling cooler (the sixth embodiment).

[FIG. 13]

FIG. 13 is a A - A cross-sectional view of FIG. 10 (the sixth embodiment).

[FIG. 14]

FIG. 14 is a cross-sectional view of the refrigerant vessel that shows the install condition of an inner fin (the

sixth embodiment).

[FIG. 15]

FIG. 15 is a B - B cross-sectional view of FIG. 12 (the sixth embodiment).

[FIG. 16]

FIG. 16 is a C - C cross-sectional view of FIG. 12 (the sixth embodiment).

[FIG. 17]

FIG. 17 is a D - D cross-sectional view of FIG. 12 (the sixth embodiment).

[FIG. 18]

FIG. 18 is a E - E cross-sectional view of FIG. 12 (the sixth embodiment).

[FIG. 19]

FIG. 19 is a view of a cooling water channel of a cooling system by water (the sixth embodiment).

[FIG. 20]

FIG. 20 is a F - F cross-sectional view of FIG. 18 (the sixth embodiment).

[FIG. 21]

FIG. 21 is a front view of the boiling cooler that shows the condition in which the refrigerant vessel is tilted (the sixth embodiment).

[FIG. 22]

FIG. 22 is a G - G cross-sectional view of FIG. 18 (the sixth embodiment).

[EXPLANATION OF NUMERALS]

(in a first to a fifth embodiments)

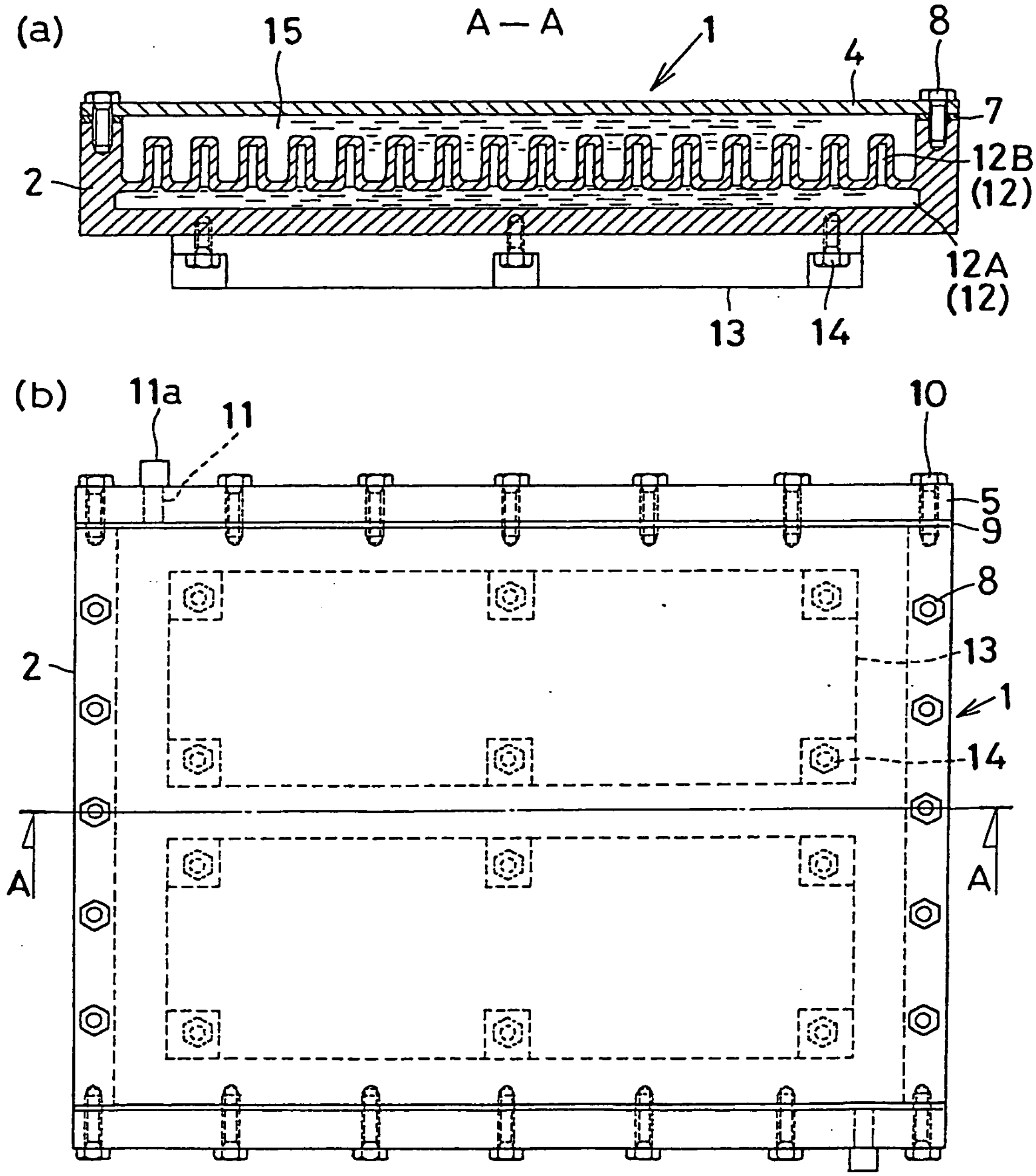
1	a heat diffusion block (a boiling cooler)
2a	a convex portion
12	a tank
12B	a radiation space (a vapor passage)
13	a heating element
15	a water passage portion (a coolant passage)
17	a cooling water channel (a coolant channel)
18	a pump
19	a radiator
21	a heat radiation fin

(in a sixth embodiment)

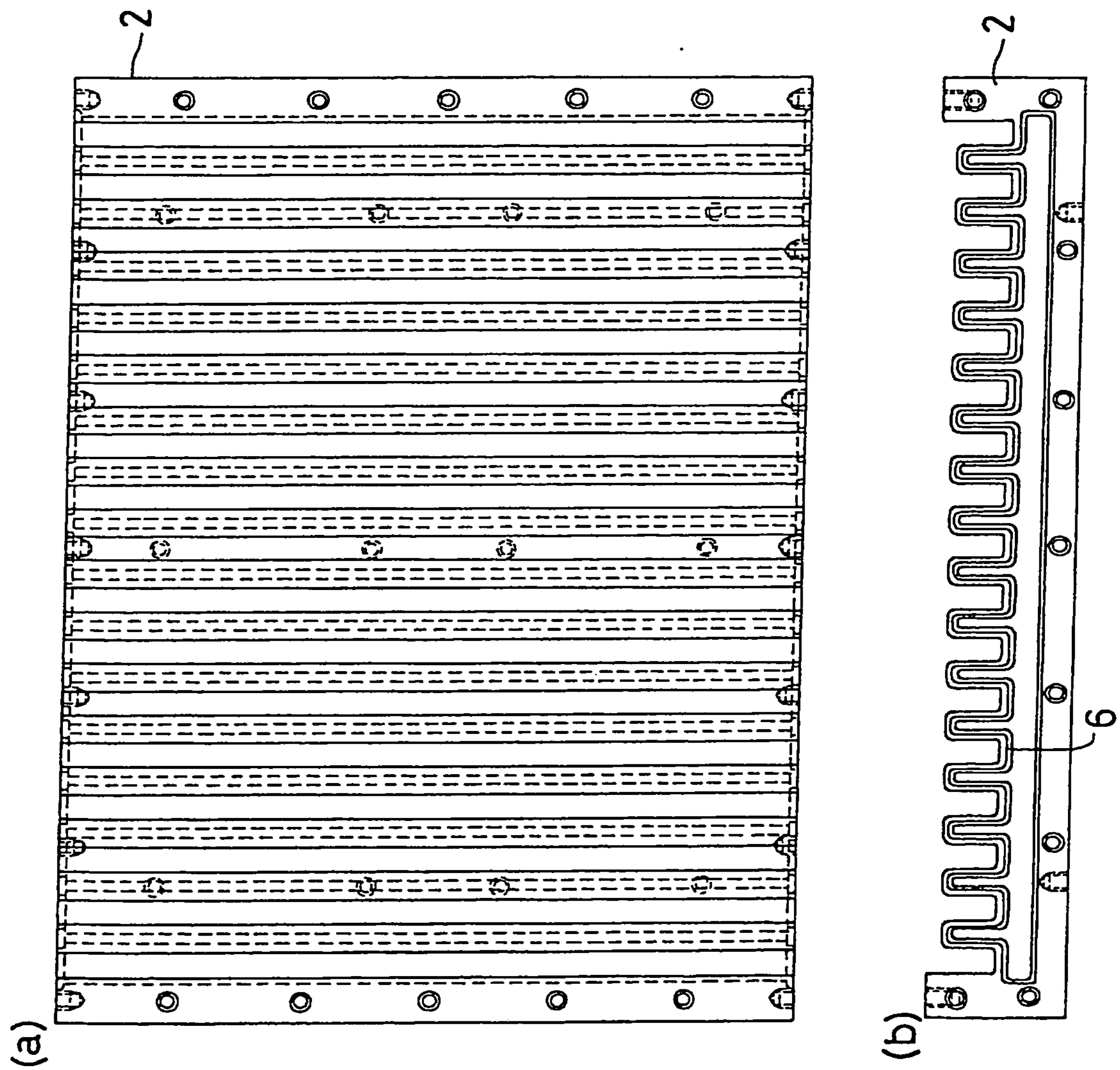
30	a boiling cooler
31	a heating element
39	a radiation passage (a vapor passage)
40	a water jacket (the coolant passage)
43	the pump
44	the radiator

[Name of Document]　Drawing
【書類名】　図面

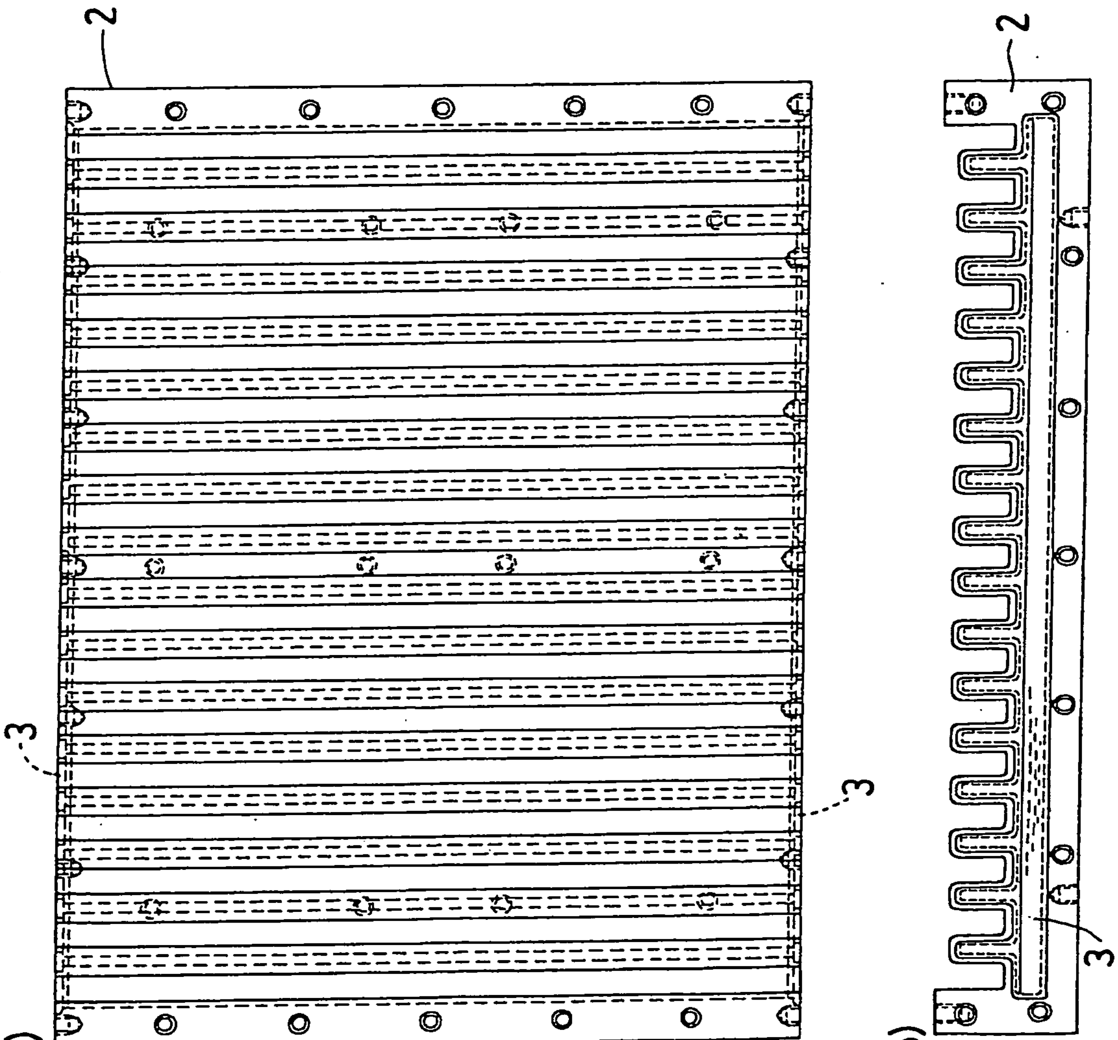
【図１】
[FIG.1]



【図２】 [FIG. 2]

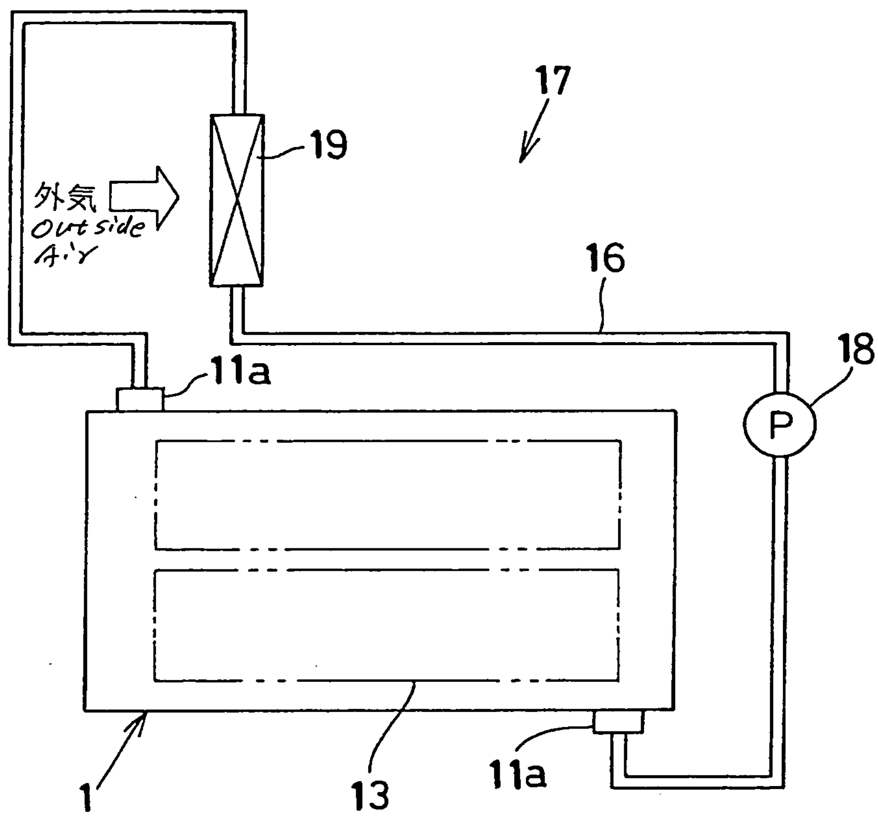


【図３】 [FIG. 3]

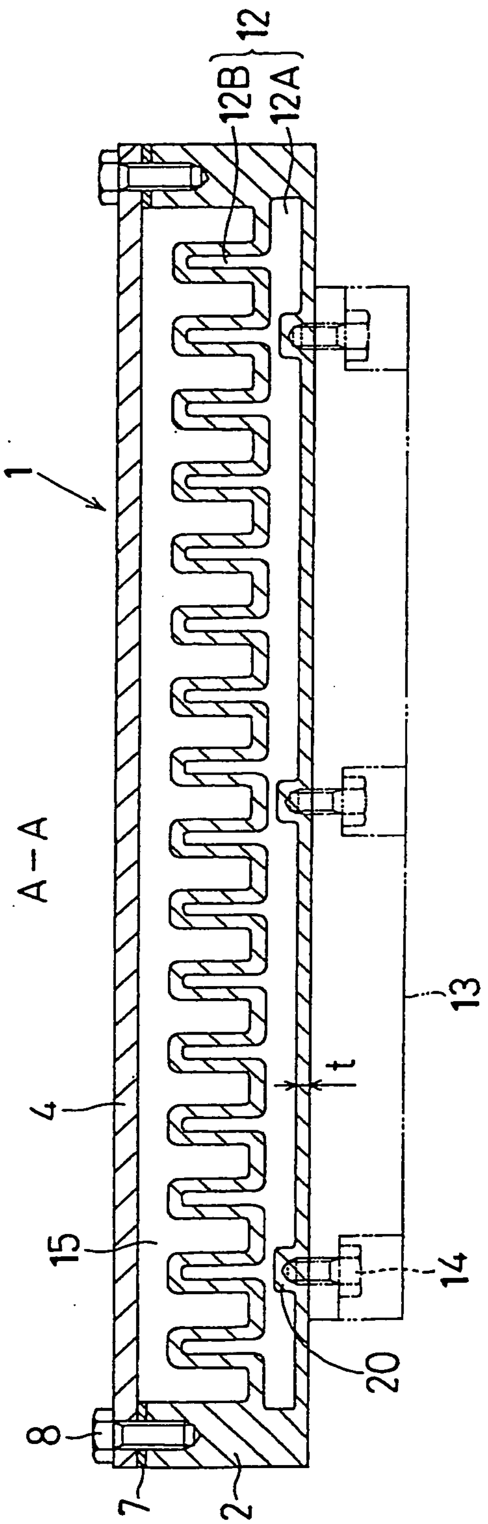


(a)　(b)

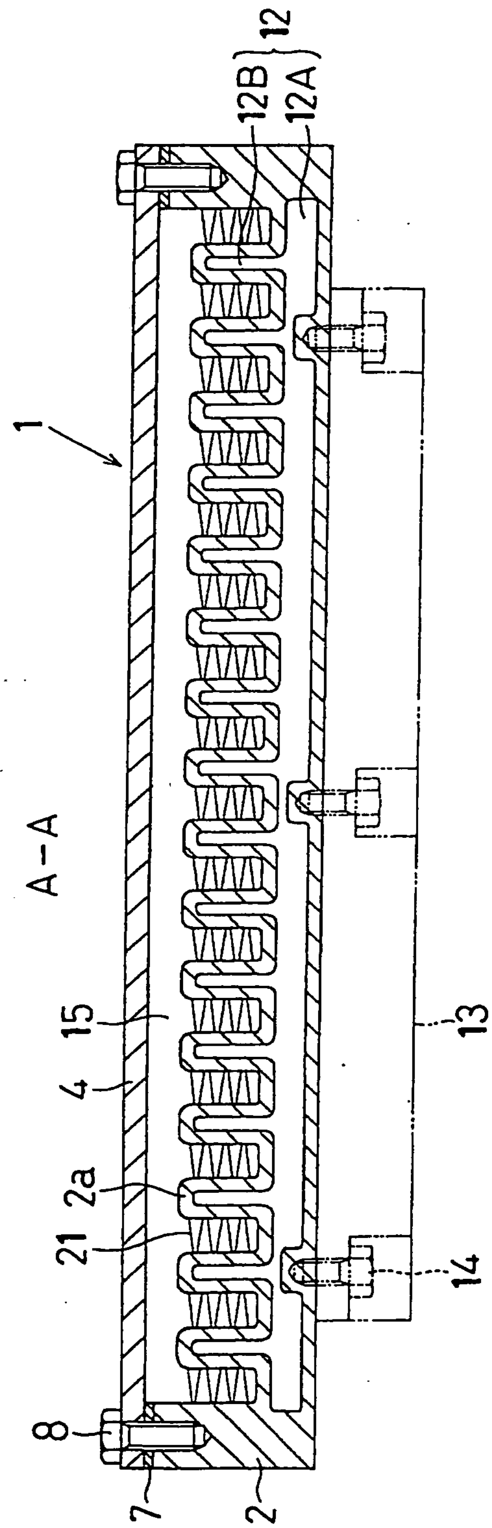
【図４】　[FIG. 4]



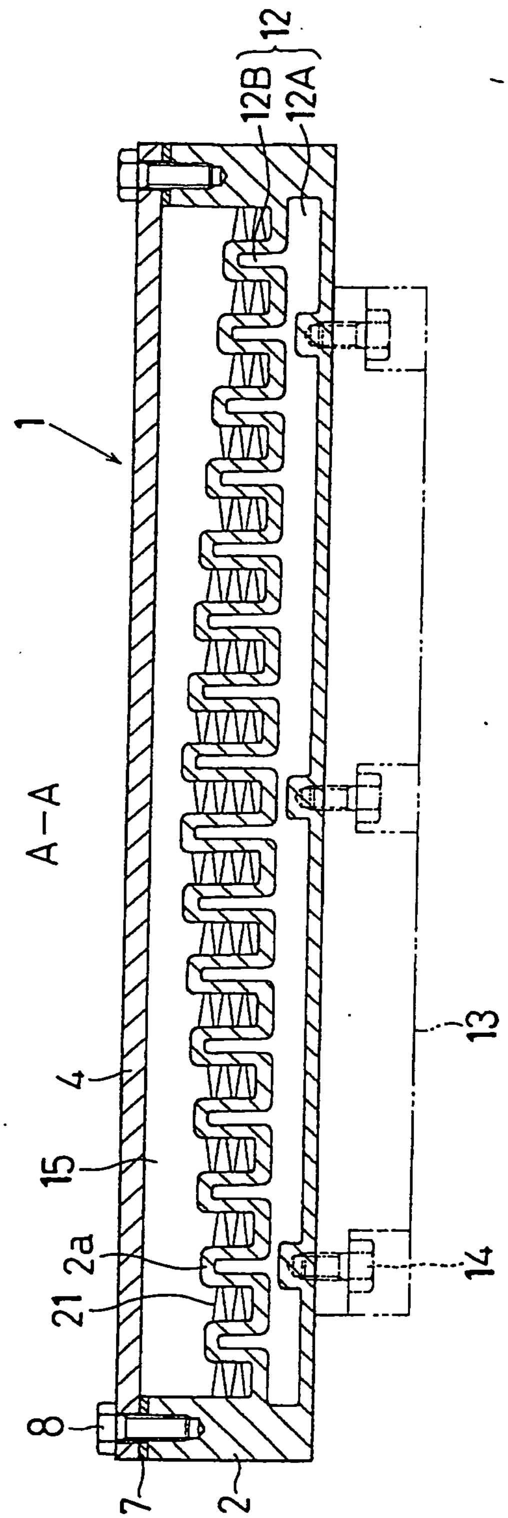
【図５】 [FIG. 5]



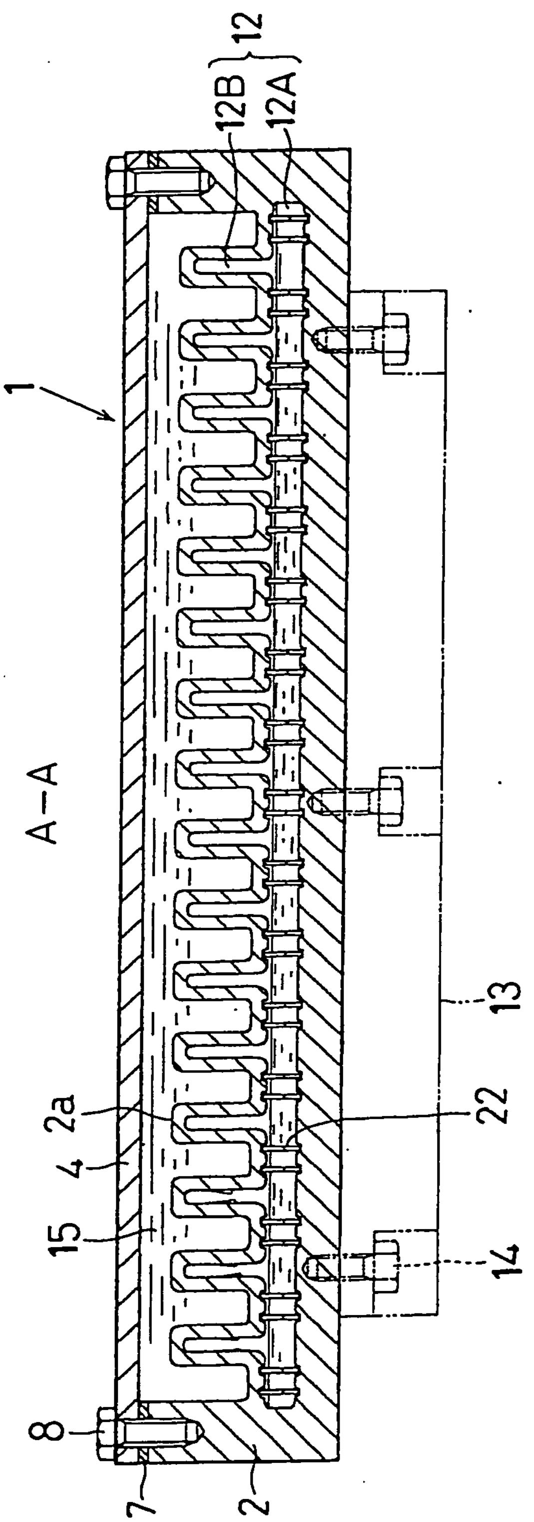
【図６】　[FIG. 6]



【図７】　[FIG. 7]

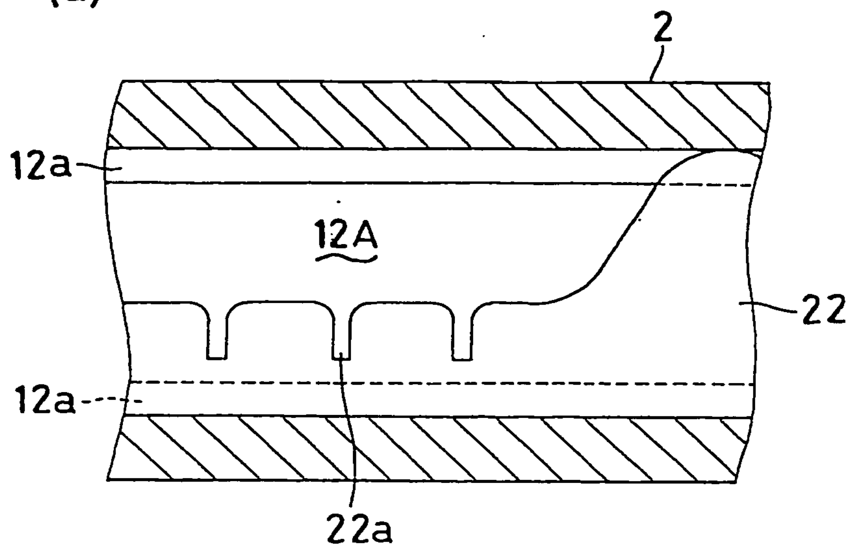


【図８】　[FIG. 8]

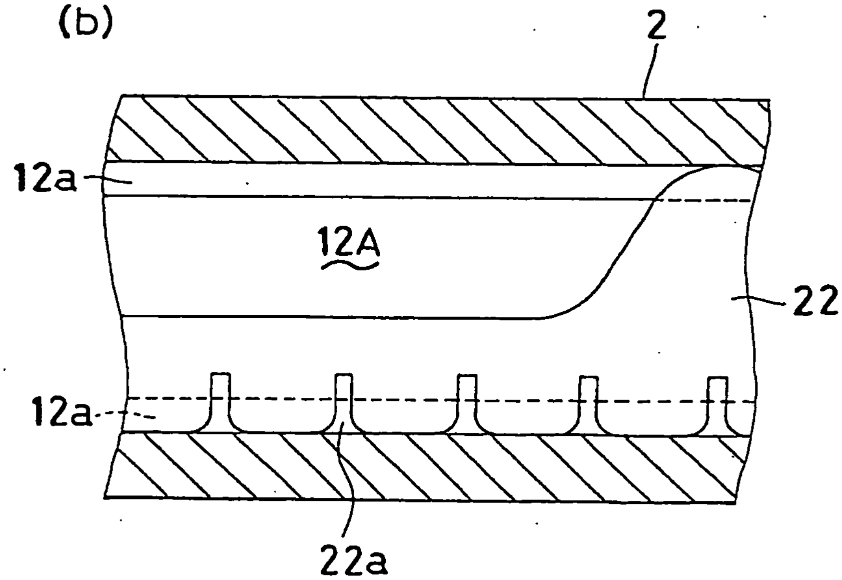


【図９】 [FIG. 9]

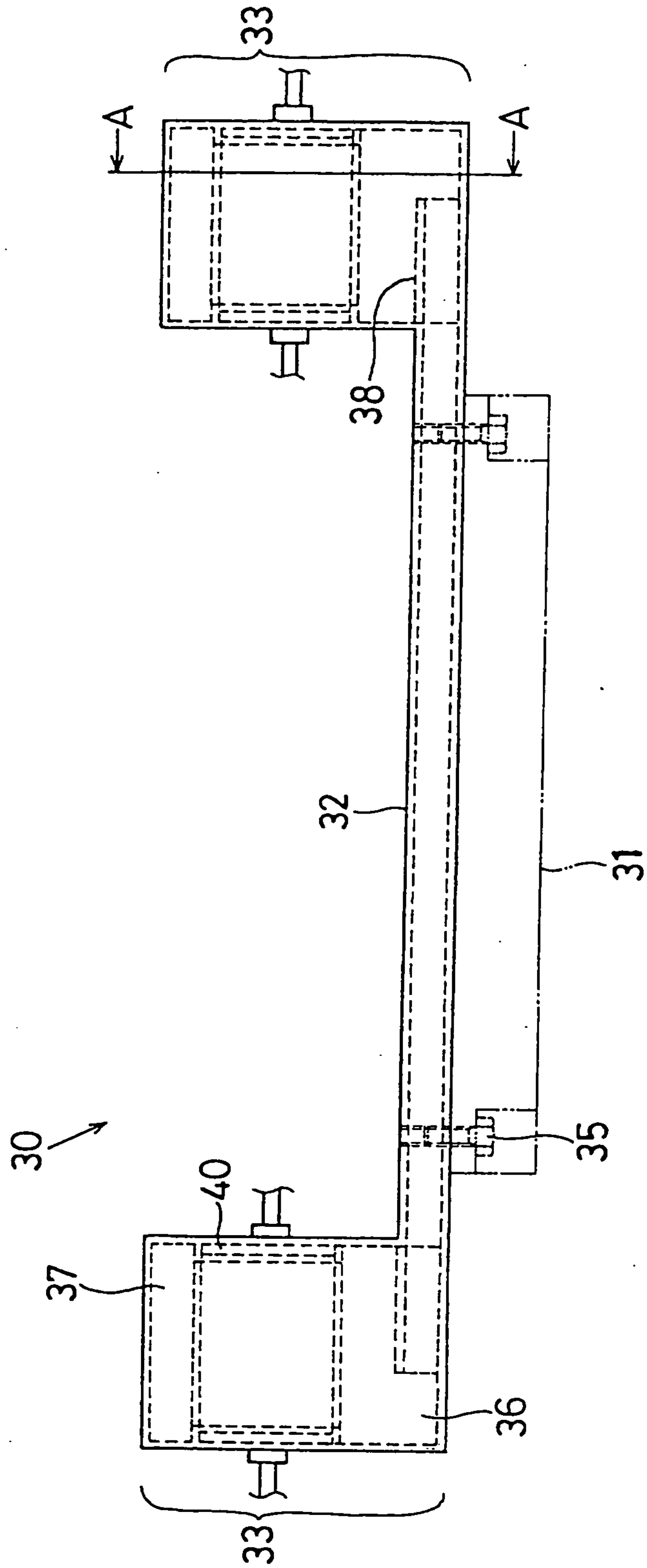
(a)



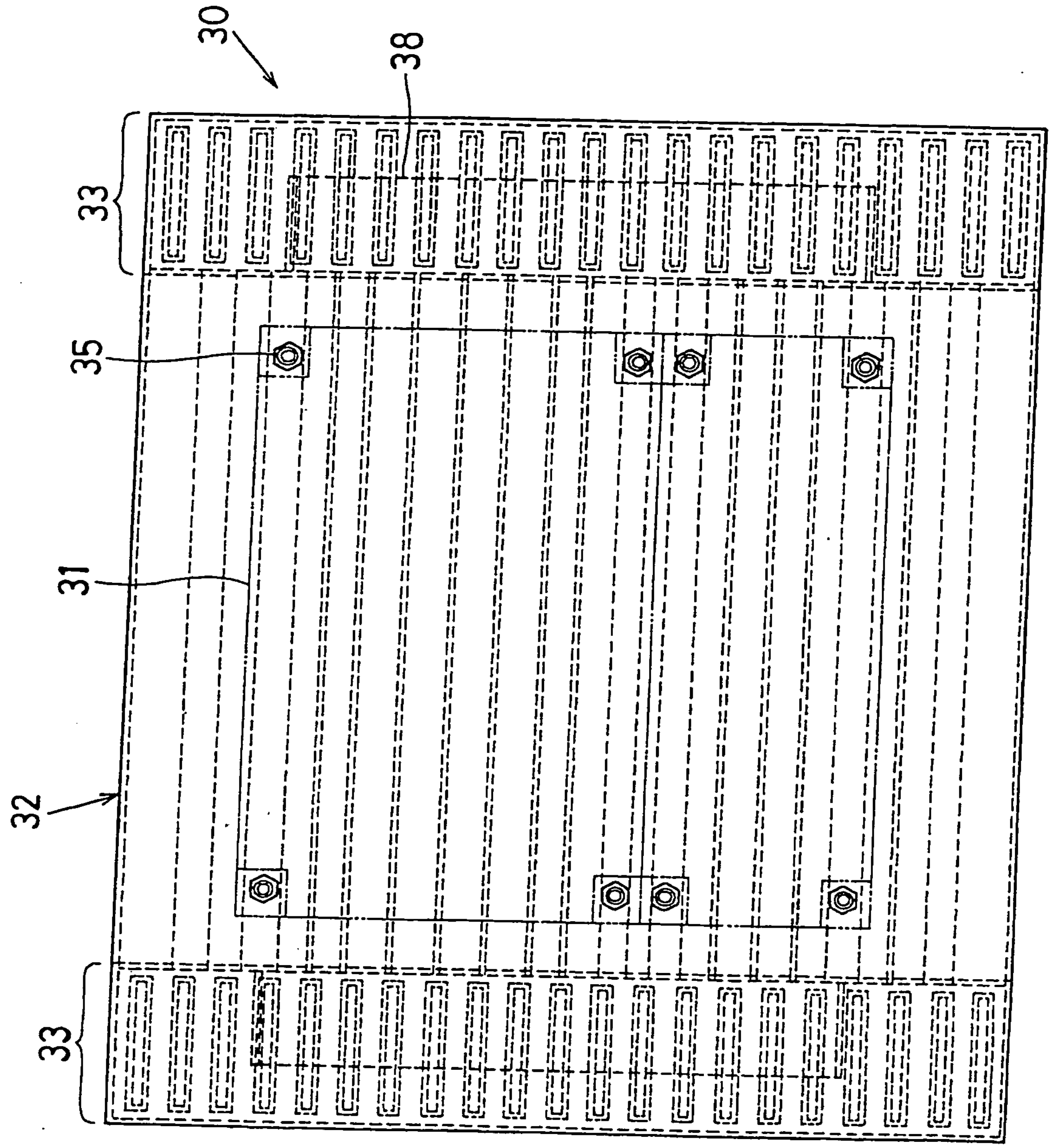
(b)



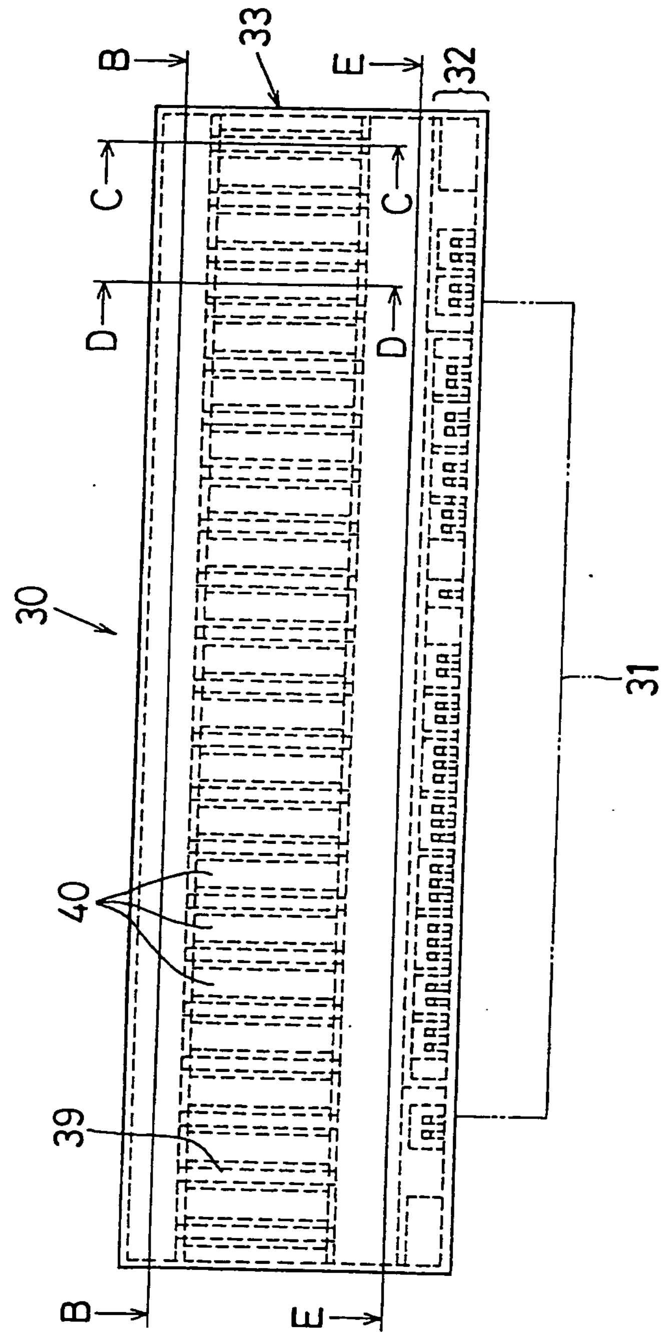
【図１０】 [FIG. 10]



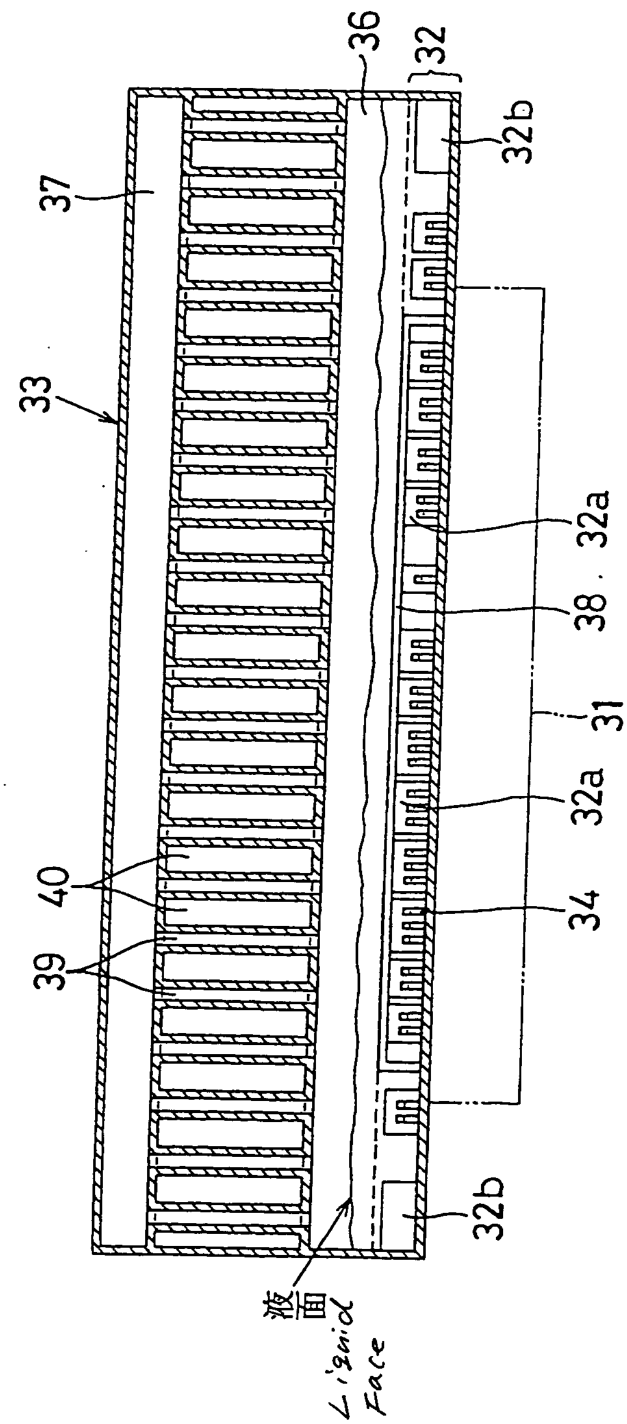
【図１１】　[FIG. 11]



【図１２】　[FIG. 12]



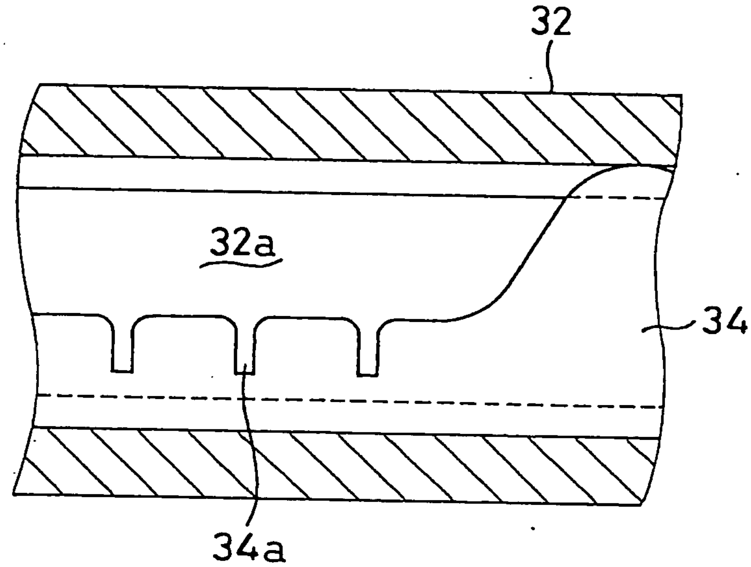
【図１３】　[FIG. 13]



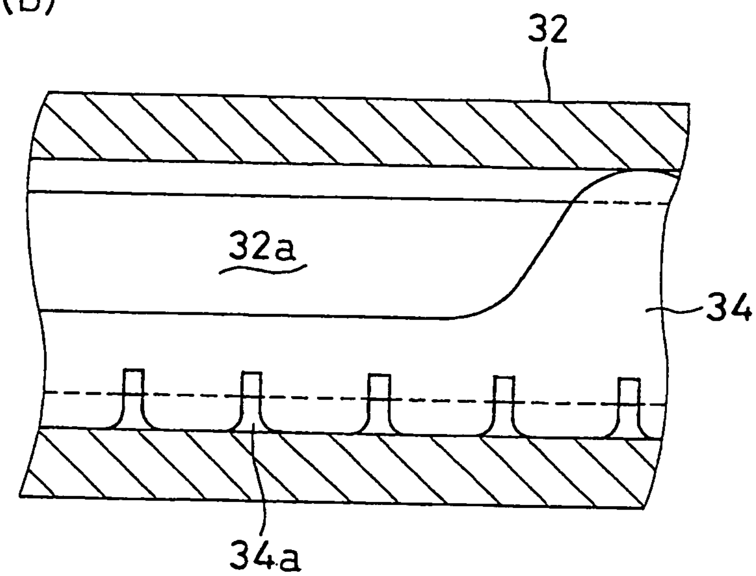
(A−A断面)
(A-A Cross-Section)

【図１４】　[FIG.14]

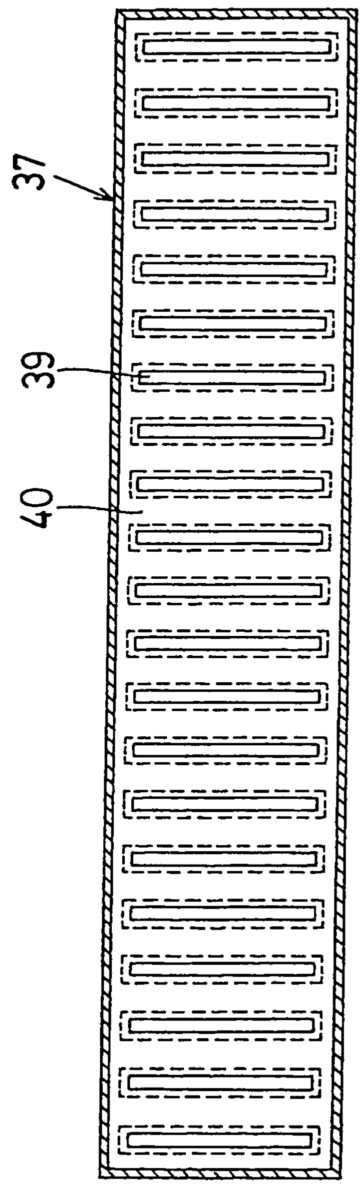
(a)



(b)

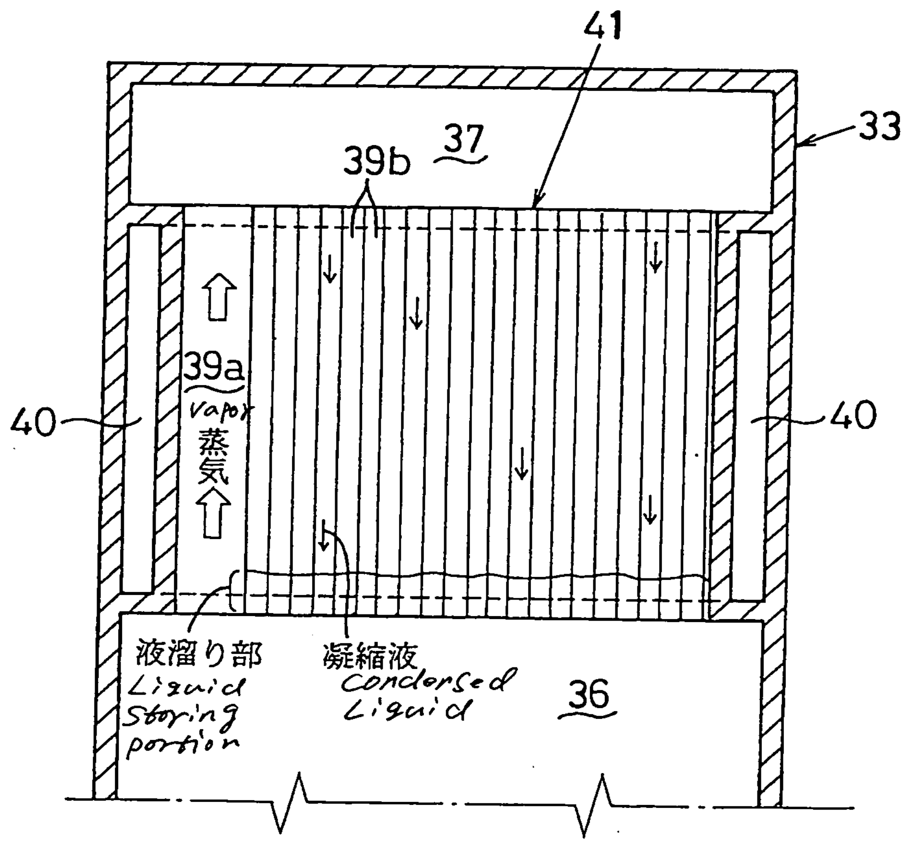


【図１５】　[FIG. 15]



（B－B断面）
(B-B cross-section)

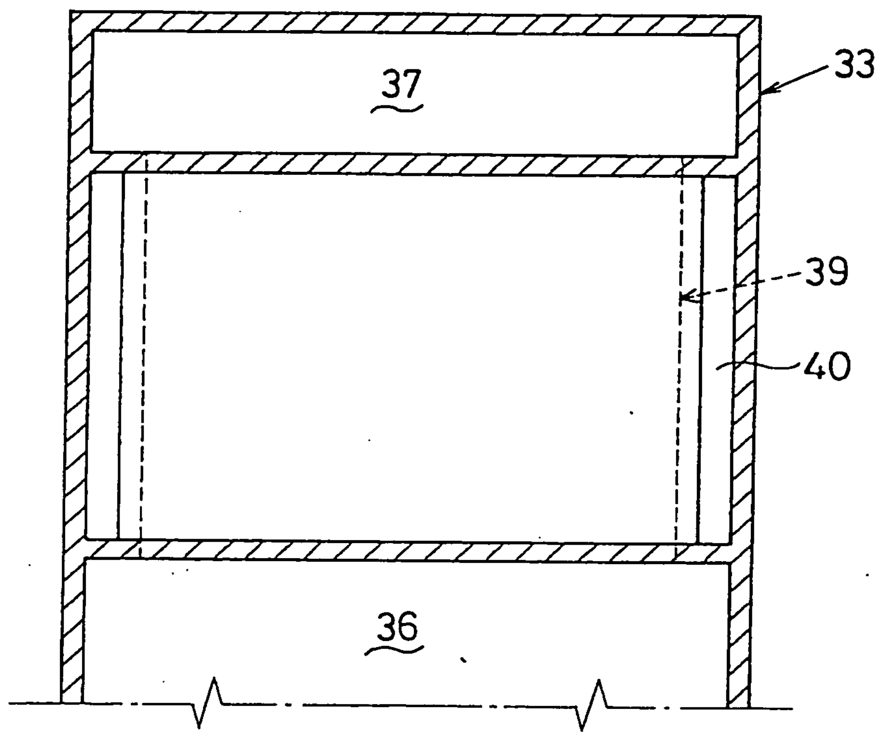
【図１６】　[FIG. 16]



（Ｃ－Ｃ断面）

(C-C cross-section)

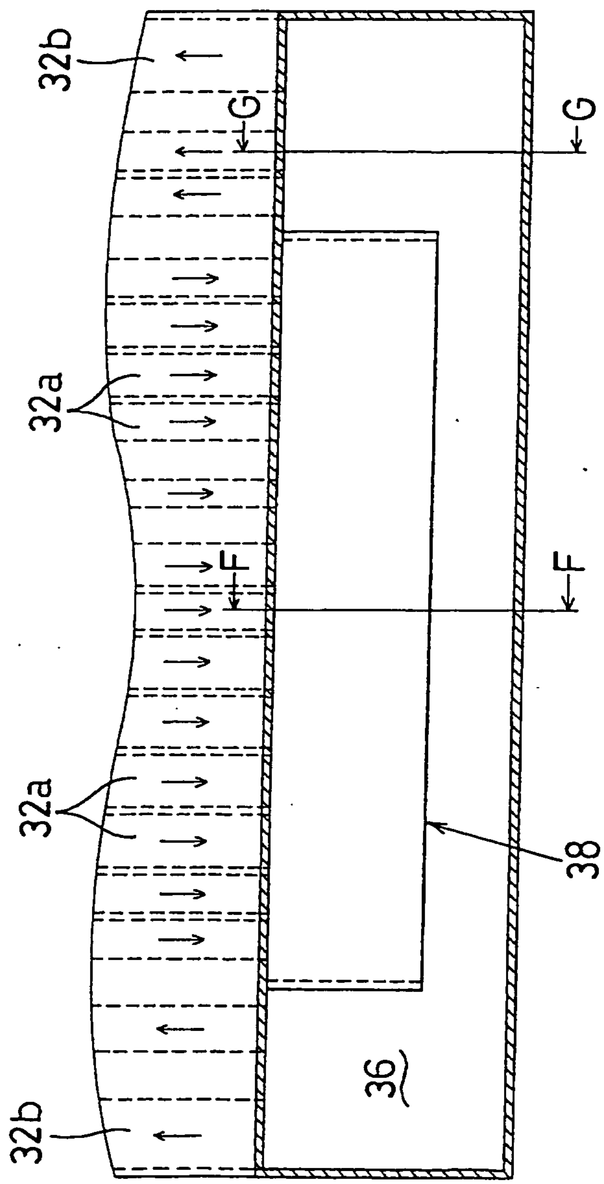
【図１７】　［FIG. 17］



（Ｄ－Ｄ断面）

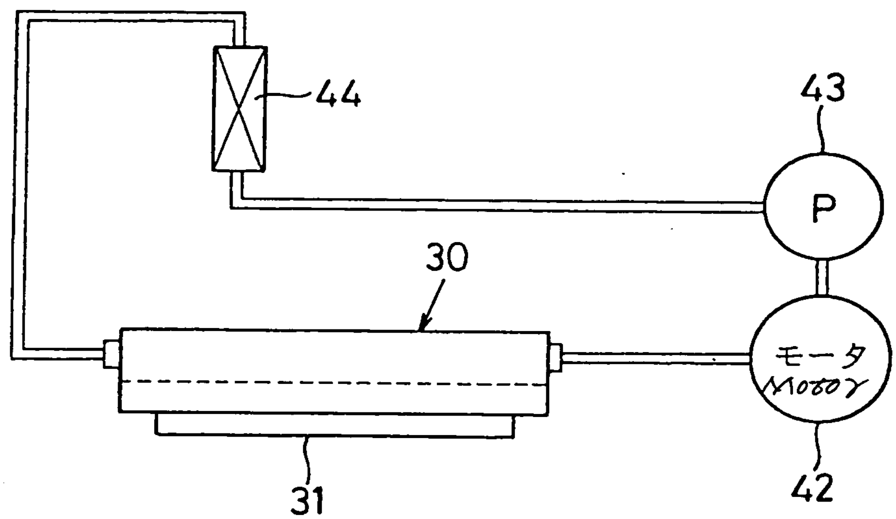
(D-D cross-section)

【図１８】　[FIG. 18]

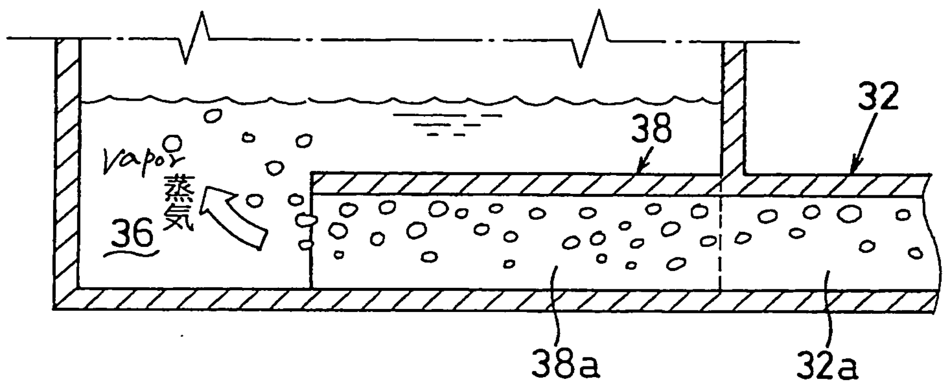


（Ｅ－Ｅ断面）
(E-E Cross-Section)

【図１９】 [FIG. 19]



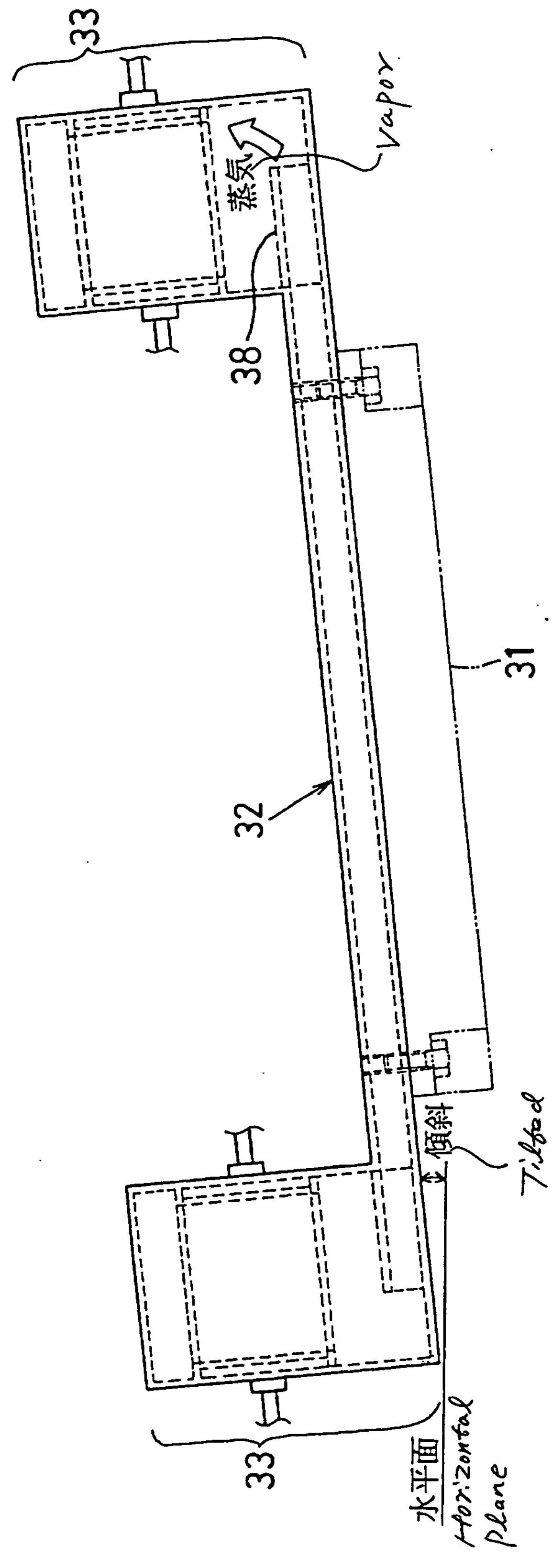
【図２０】 [FIG. 20]



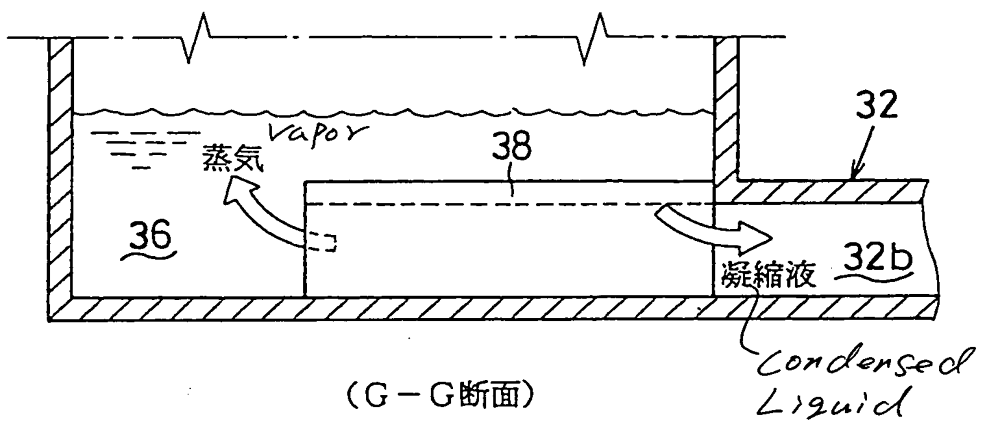
（Ｆ－Ｆ断面）

(F-F Cross-Section)

【図２１】　[FIG. 21]



【図２２】　[FIG. 22]



（Ｇ－Ｇ断面）

(G-G cross-section)

[NAME OF THE DOCUMENT] ABSTRACT OF THE DISCLOSURE

[ABSTRACT]

[OBJECT]

It is an object of the present invention to provide a boiling cooler (a heat diffusion block 1) which is less constrained by the arrangement, and has a higher mountability.

[MEANS FOR SOLVING PROBLEMS]

A heat diffusion block 1 forms a sealed tank 12 with a hollow space in a block body 2 covered by two side plates. The tank 12 is composed of a refrigerant chamber 12A which is small in height and large in the left-right and front-rear direction, and a radiation space 12B in a convex shape that protrudes upward from the refrigerant chamber 12A. Further, the refrigerant chamber 12A is filled with a liquid refrigerant up to the approximate height of the chamber. In addition, a water passage 15 is provided with a hollow space that is defined between the concavo-convex portions of the block body 2 and the upper lid 4, closed with two outer plates 5. Cooling water flows in the water passage 15.

The refrigerant vapor boiled and gasified by the heating element 13 is cooled by the cooling water that flows in the water passage 15 and condensed on the inner wall of the tank 12 to form drops, and then drips down to the refrigerant chamber 12A to return to a part of the liquid refrigerant.

[SELECTED FIGURE] FIG. 1